Reciprocating compressor instrumented for machinery management

by ***Don Silcock***
Bently Nevada Corporation

The successful introduction of Predictive Maintenance has played a major role in reducing maintenance costs and extending the life of rotating equipment at Incitec's Gibson Island Works. Now, Incitec has extended its program to critical reciprocating compressors.

Incitec's Gibson Island Works in Brisbane, Australia, consists of ammonia, prilled urea, carbon dioxide and granulated fertilizer plants. The urea plant has two reciprocating compressors that are critical to the process, and shutdown of either results in a 50% reduction in plant rates. As part of Incitec's continuous improvement program, management decided to upgrade the original "malfunction detector" vibration switches installed on the compressors.

The two compressors are basically identical, and consist of two ammonia and five CO_2 stages, configured on six crankshaft throws (the fourth and fifth stages are combined) (Figure 1).

Incitec's requirements

For these critical reciprocating compressors, Incitec wanted a monitoring and diagnostic system that would fit well with their existing Predictive Maintenance program, and provide actionable information to improve the management of the machines. They also wanted to ensure that maintenance work performed during periodic outages was based on objective, rather than subjective, assessments of machine condition.

The monitoring and diagnostic system would be able to:

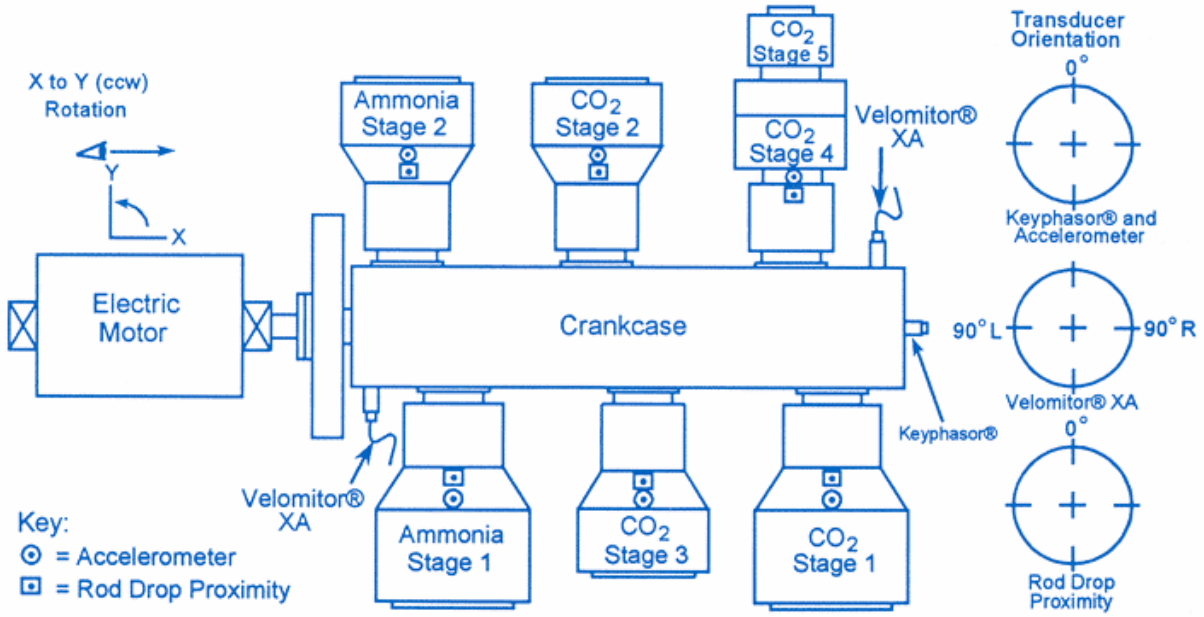

Figure 1
Overall machine layout, showing transducer locations and orientation.

- Identify crankshaft-related faults, such as wear on the main, big and little end bearings.
- Monitor individual compressor stages, indicate piston looseness, and protect against sudden piston failure.
- Measure wear on the rider rings on each compressor stage.
- Monitor the condition of each of the 58 suction and discharge valves.

Furthermore, maintenance personnel insisted that the system not interfere with machine maintenance, particularly around the cylinder heads.

Incitec decided to retrofit one compressor in early 1995, and if successful, retrofit the second unit in 1996.

Bently Nevada's solution

Incitec asked Bently Nevada to recommend a system that would meet these objectives. In late 1994 and early 1995, Bently Nevada engineers and salesmen worked closely with plant maintenance personnel to design and install the system. Bruce Greer and Ian Uhlmann, of Incitec's Technical Support Group, contributed innovative ideas for this comprehensive solution.

Identify crankshaft-related faults with Velomitor® XA Sensors

Compressor crankshaft and bearing faults are identified through crankcase vibration measured in the horizontal plane. Incitec installed one Bently Nevada Velomitor® XA (Extended Application) sensor at each end of the crankcase. Both were installed horizontally on the crankcase centerline, adjacent to the original malfunction detectors.

The Velomitor® XA sensor's 4.5 Hz to 2 kHz frequency response is ideal for measuring vibration that originates at the crankshaft, which turns at 330 rpm. The Velomitor® XA sensor is an easy-to-install, weatherproof piezovelocity sensor.

Signals from the Velomitor XA sensors are processed by a Bently Nevada 3300/55 Dual Velocity Monitor. The 3300 Monitoring System is Bently Nevada's industry-standard monitoring system, with field-programmable options and many safety features. The 3300/55 continuously monitors crankcase vibration, has alarms and relays for machine protection and buffered outputs for connection to diagnostic equipment.

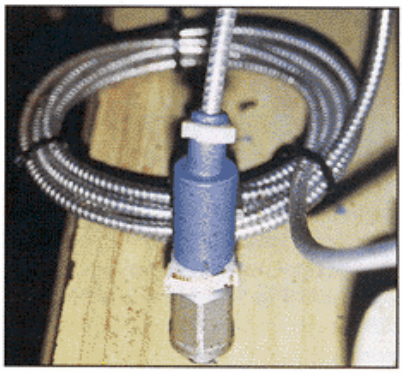

Figure 2

Accelerometer mounted vertically

Monitor individual compressor stages with accelerometers

Vibration information that can identify problems in individual stages is acquired by six accelerometers. They are installed vertically on the transition sections which connect the cylinders to the crosshead slipper guides (Figure 2). Incitec chose Bently Nevada 23732 Accelerometers, because their broad frequency response (10 Hz to 20 kHz) is perfect for measuring the high frequency signals generated by impacts associated with piston rod looseness and knocking.

Only six accelerometers were required to monitor the seven stages, because a single accelerometer monitors the combined fourth and fifth stage CO_2 cylinder. The accelerometers are connected to three Bently Nevada 3300/25 Dual Acceleration Monitors.

Indicate rider ring wear with a rod drop measurement

Rod drop measurements are made on all stages that have rider rings (the fifth, CO_2, stage does not). At each monitored cylinder, a Bently Nevada 11 mm proximity probe is mounted vertically on the crosshead oil wiper stuffing box, where it measures the relative position of the piston rod. A Keyphasor® transducer observes a notch on the crankshaft. The signals from the rod drop and Keyphasor transducers are processed by a Bently Nevada 3300/80 Rod Drop Monitor.

The rod drop transducer is a proximity probe that measures the distance between the fixed probe and the moving piston rod (Figure 3). That distance changes as the rider rings wear. The 3300/80 Rod Drop Monitor displays actual rider ring wear, rather than the distance between the probe and piston rod. It uses the Keyphasor signal to identify the best point in the piston stroke to measure rod drop (See "Rider band wear measurement in reciprocating compressors," in the

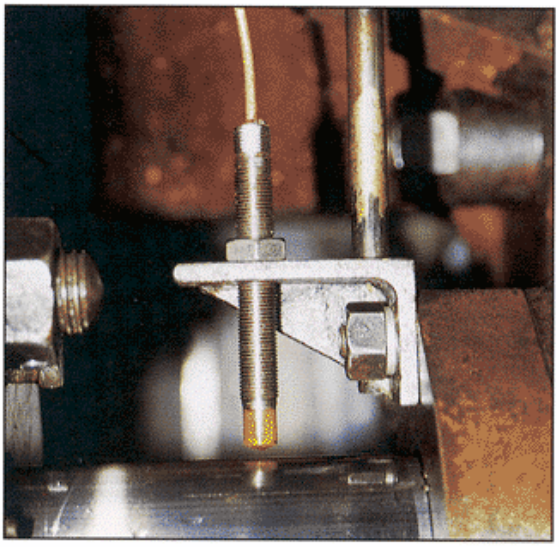

Figure 3

Rod drop proximity probe installation

"Incitec specified a reciprocating compressor monitoring system that would not interfere with compressor maintenance."

December, 1995 issue of the Orbit). The 3300/80 Rod Drop Monitor has all of the reliability and machinery protection features that have made the 3300 Monitoring System the industry standard.

Monitor valve condition through temperature measurements

Valve condition is indicated by the gas temperature near each of the 58 suction and discharge valves. A thermocouple mounted near each valve measures the gas temperature. Each thermocouple is installed in a hole drilled through the core of a stainless steel screw. The screw and thermocouple assembly is installed in place of the jacking screw on each valve cover (Figure 4).

The 58 thermocouples are connected to two 3300/75 Reciprocating Compressor Valve Temperature Monitors. Each 3300/75 can monitor the signals from up to 32 thermocouples or RTDs, through Bently Nevada's scanning technology. Each thermocouple is attached to a Transducer Interface Module (TIM), which assigns it a unique address. Up to 32 TIMs connect to a 3300/75 through a single 5-wire cable. The 3300/75 continually scans the TIMs; it scans 32 TIMs in approximately 5 seconds. The 3300/75 displays temperature in several different ways, and it incorporates Bently Nevada's 3300 System reliability and machinery protection features.

Maintainability

Incitec specified a reciprocating compressor monitoring system that would not interfere with compressor maintenance. Careful installation ensured that the Velomitor XA Sensors, the 23732 Accelerometers and the rod drop proximity probes didn't interfere with maintenance work. However, the 58 thermocouples required an innovative approach. Each thermocouple was connected to a quick-release bayonet connector, so it could be quickly disconnected when maintenance was required.

The steel ducting, which routes the wires along the sides of the cylinders, consists of folding sections. When large-scale maintenance is required, the thermocouples can be quickly disconnected and bundled together, the steel ducting folded down, and all the wiring placed underneath the floor grating. This innovative design makes it easy for a mechanic to clear all instrumentation from a cylinder in minutes, and permits unrestricted access for machine maintenance.

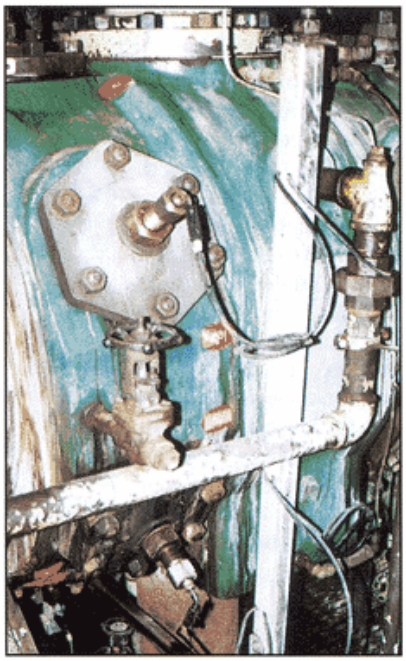

Figure 4

Valve cover and jacking screw showing installation of thermocouple

Online diagnostic system

Incitec has had considerable success in managing critical compressor trains with Bently Nevada's Transient Data Manager® 2 (TDM2) online diagnostic system. TDM2 is a permanently-installed online diagnostic system for critical machinery. It automatically collects and stores data at predefined intervals and also when an alarm occurs, during both steady-state and transient operation. TDM2 graphs data in several formats, for fast and accurate machinery diagnostics. Incitec believed that successful reciprocating machine management depends on the ability to trend vibration data, and to capture data when machine alarms occur.

Therefore, Incitec installed a 3300 Monitoring System that included Bently Nevada's built-in Dynamic Data Interface (DDI) and Serial Data Interface (SDI). The DDI transmits data between the monitoring system and the TDM2, which compiles vibration trends and captures data when alarms occur. The SDI communicates monitoring system data to the plant's Distributed Control System, so operations personnel can monitor vibration and temperature data.

Instrumented for machinery management

Incitec's new monitoring system is now an important tool for managing the operation of the urea plant. The monitoring system protects the machine from catastrophic failure. The TDM2 online diagnostic system helps Incitec to manage the machine in a way that extends its lifespan and makes maintenance turnarounds faster and less expensive. Incitec is currently planning to retrofit the urea plant's other critical reciprocating compressor. ■